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Ecosystem carbon balance under future climate conditions: The CLIMAITE project carbon synthesis.

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The potential changes in ecosystem carbon stocks and fluxes under predicted future climatic conditions and the consequent feedback to the atmosphere is a major source of uncertainty in assessing the future atmospheric radiative forcing by greenhouse gases. Hypotheses on the impact of future climate on carbon fluxes such as primary production, CH₄ exchange, below ground carbon allocation, soil respiration and net ecosystem exchange (NEE) have been proposed and many experimental and monitoring studies have been conducted during recent decades. Testing of ecosystem scale hypotheses requires the integration of measurements made at a broad range of scales from leaf-level to ecosystem into a consistent framework that considers the suite of ecosystem stocks and fluxes. In this study, a field scale climate change experiment, CLIMAITE, was carried out involving a multifactorial approach with elevated CO₂ (FACE CO₂ 510ppm) Temperature (T +1°C night-time warming) and Drought (D ~20% reduction annual precipitation) in a heathland ecosystem (Mikkelsen, T.N., *et al.*, 2008, Functional Ecology, pp185-195). Hypotheses related to the carbon balance in the terrestrial ecosystem were tested with an annual carbon budget for constructed for each treatment of the experiment.

The carbon stocks and fluxes were variously measured and upscaled to produce annual areal budgets for the eight (8) different experimental treatments and reconciled with measured changes in stocks over the first two years of experimental treatment. The initial carbon stocks ranged over 3 orders of magnitude and were SOM (~4400 gC m⁻²), plant (~600 gC m⁻²), soil microbial (~30 gC m⁻²), soil fauna (~1.4 gC m⁻²) and above ground insects (~0.1 gC m⁻²). The fluxes were estimated to be photosynthesis (~1100 gC m⁻² a⁻¹), plant respiration (~760 gC m⁻² a⁻¹), litter production (~240 gC m⁻² a⁻¹), microbial respiration (~180 gC m⁻² a⁻¹), DOC leaching (~40 gC m⁻² a⁻¹) and animal respiration (~9 gC m⁻² a⁻¹). Overall, the system was a small carbon sink and the budget will be continuously improved as better measurements become available.

The differences in the budgets across treatments are attributable to treatment related differences in fluxes of above ground litter fall, up-scaled photosynthetic production and soil and ecosystem respiration. Elevated temperature alone (T), drought (D) and in combination with drought (T+D) reduced the upscaled photosynthesis. In combination with increased plant respiration, in the T, D and T+D treatments and increased microbial respiration in T treatment, the system changed from a small net sink in the ambient (control) treatment, to a small net source of carbon in the T and T+D treatments. Treatments containing CO₂ enrichment, however, compensated for this loss in productivity through decreased stomatal conductance and therefore improved water use efficiency; CO₂ enriched plots were generally larger carbon sinks than the control treatment.

We conclude that the nature and short term changes of the system as a net carbon sink or source is dependant on the interaction between the different aspects of global change. The study also highlights the importance of multi-factorial experiments to assess the effects of projected climate conditions on ecosystem carbon balance and the potential changes in atmospheric feedback. The long term sustainability of the observed effects need further testing in longer term experiments and studies.